COGS500/CMPE489
Introduction to Cognitive Science

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With slides adapted from Albert Ali Salah

Today

- Grades
- Psychology
- Nervous system

Last Weeks

- Introduction to Cognitive Science
- Some philosophical background
- Artificial Intelligence lecture by Cem Say
- Introduction to Artificial Intelligence
  - What is intelligent agent.
  - How to form problem.
    - Action, state space, goal state, utility function.
  - How to do simple search.

Cognitive View

- Human mind, complex system,
  - Receives, stores, retrieves, transforms, transmits
  - Operations on information: Computations and information processes.
- The view of mind: computational or information-processing view.

PSYCHOLOGY

Definition of Psychology

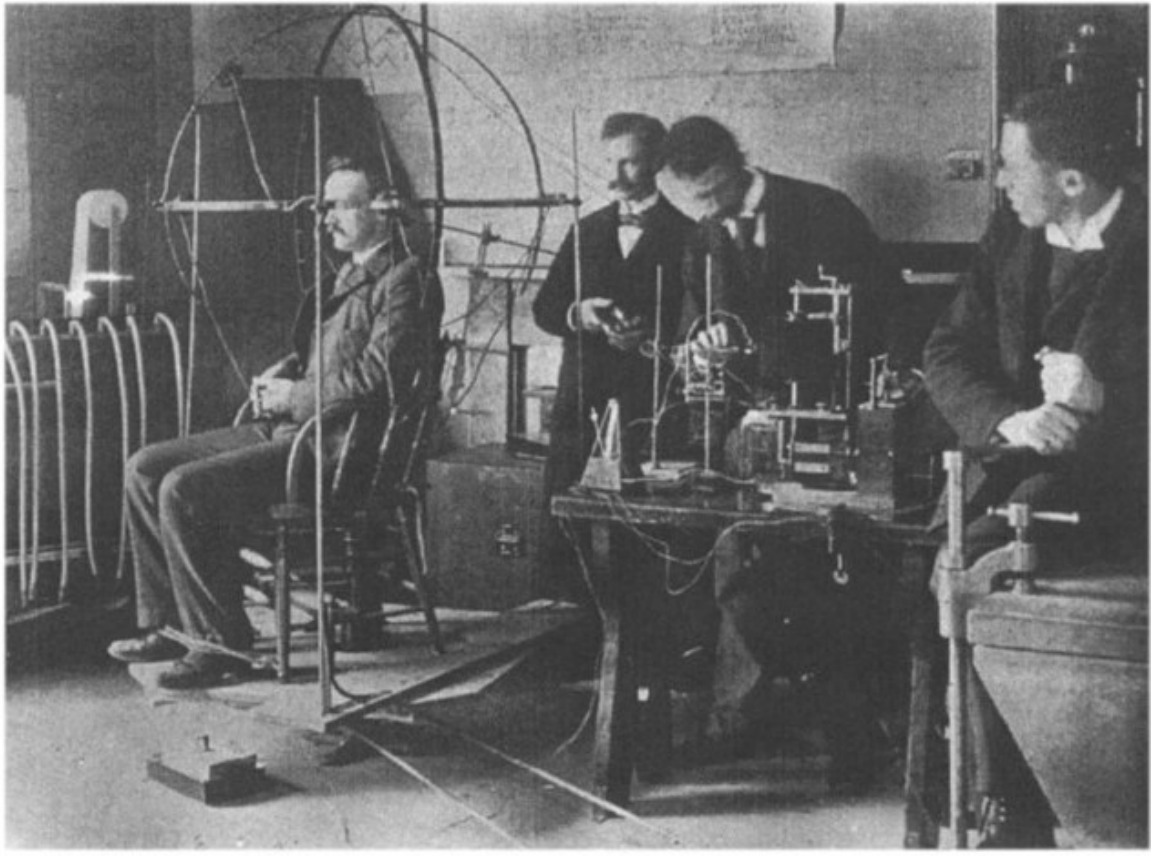
- “The scientific study of behavior and mental processes.” (Atkinson et al.)
- It should be objective: Repeatability
- It should be unbiased: No hypothesis is favored

Nature–nurture debate

- Nature - nurture debate centers on the question of whether human capabilities are inborn or acquired through experience
- Early philosophers believed that this knowledge and understanding could be accessed through careful reasoning and **introspection**.

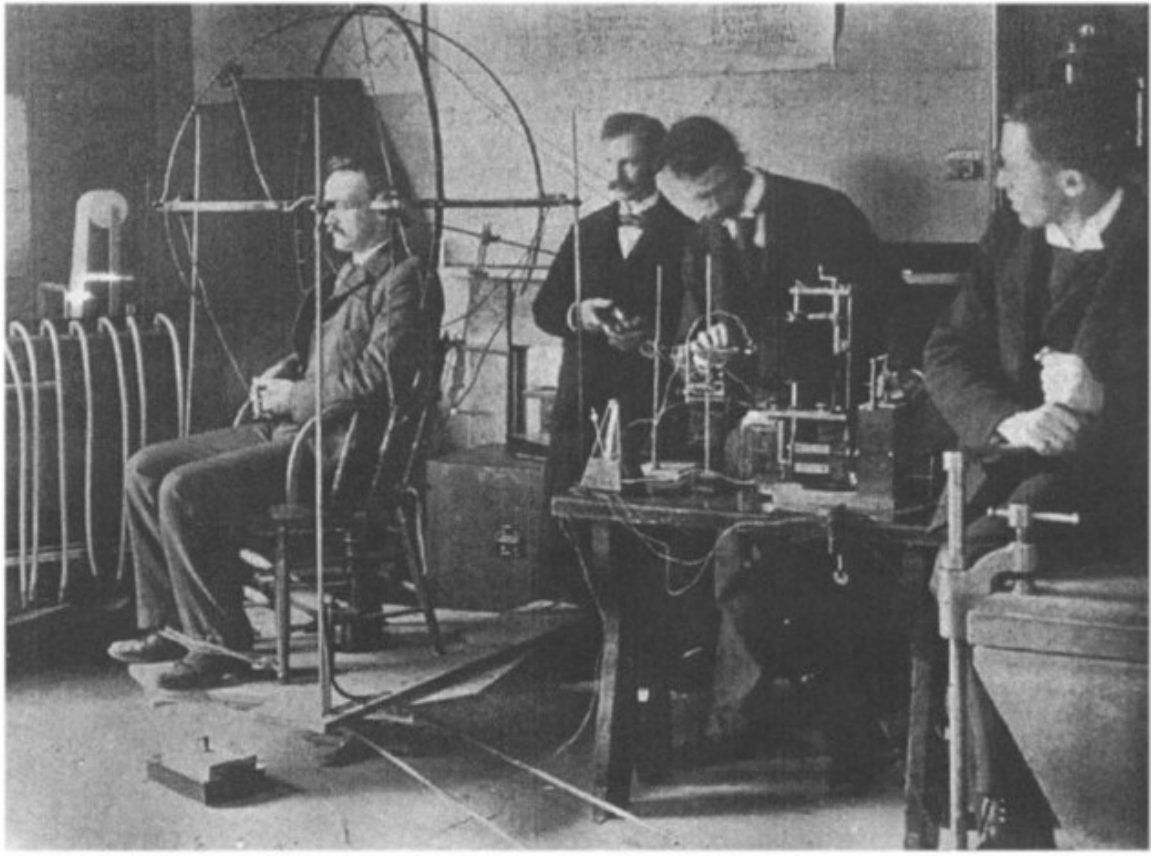
Introspection

- 1879, Wilhelm Wundt established the first psychological laboratory in Leipzig
- Mind and behavior subject of scientific analysis.
- A new dimension. Pure self-observation was not sufficient; it had to be supplemented by experiments.



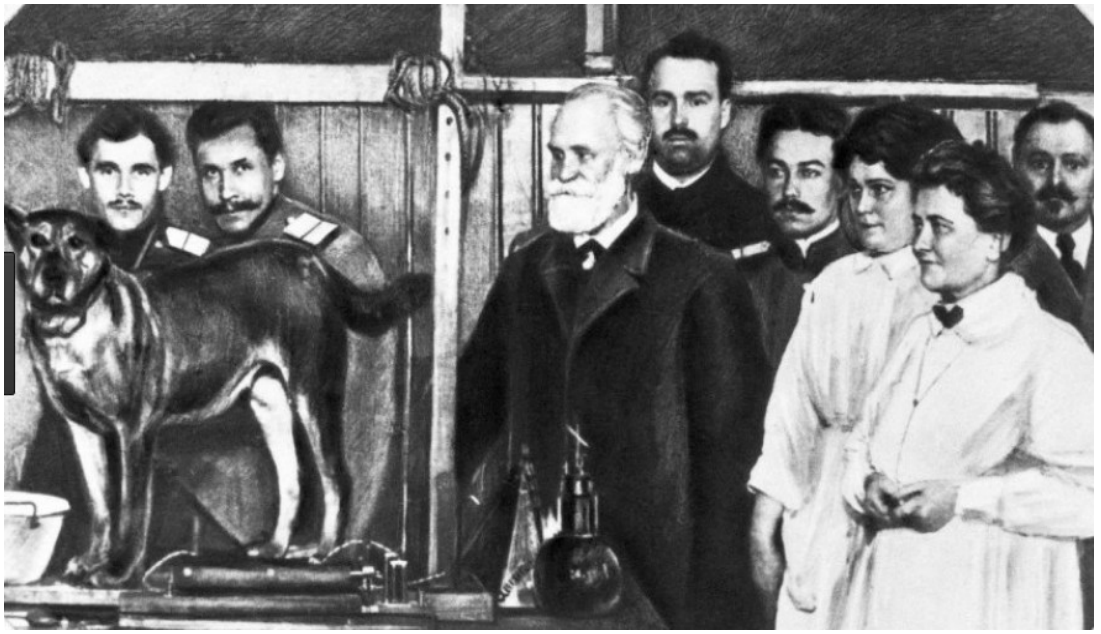
Introspection

- Not reliable, not repeatable, inconsistent

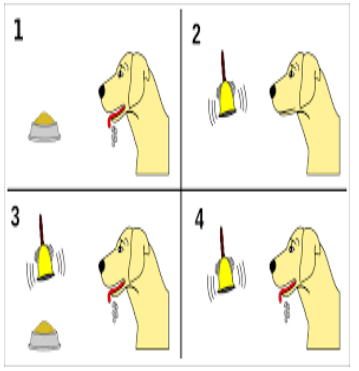


Behaviorists

The Little Albert Experiment (1920)
Source:youtube



Ivan Pavlov's dogs
Source:spiegel.de



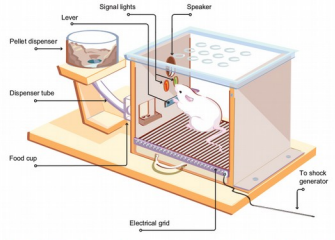
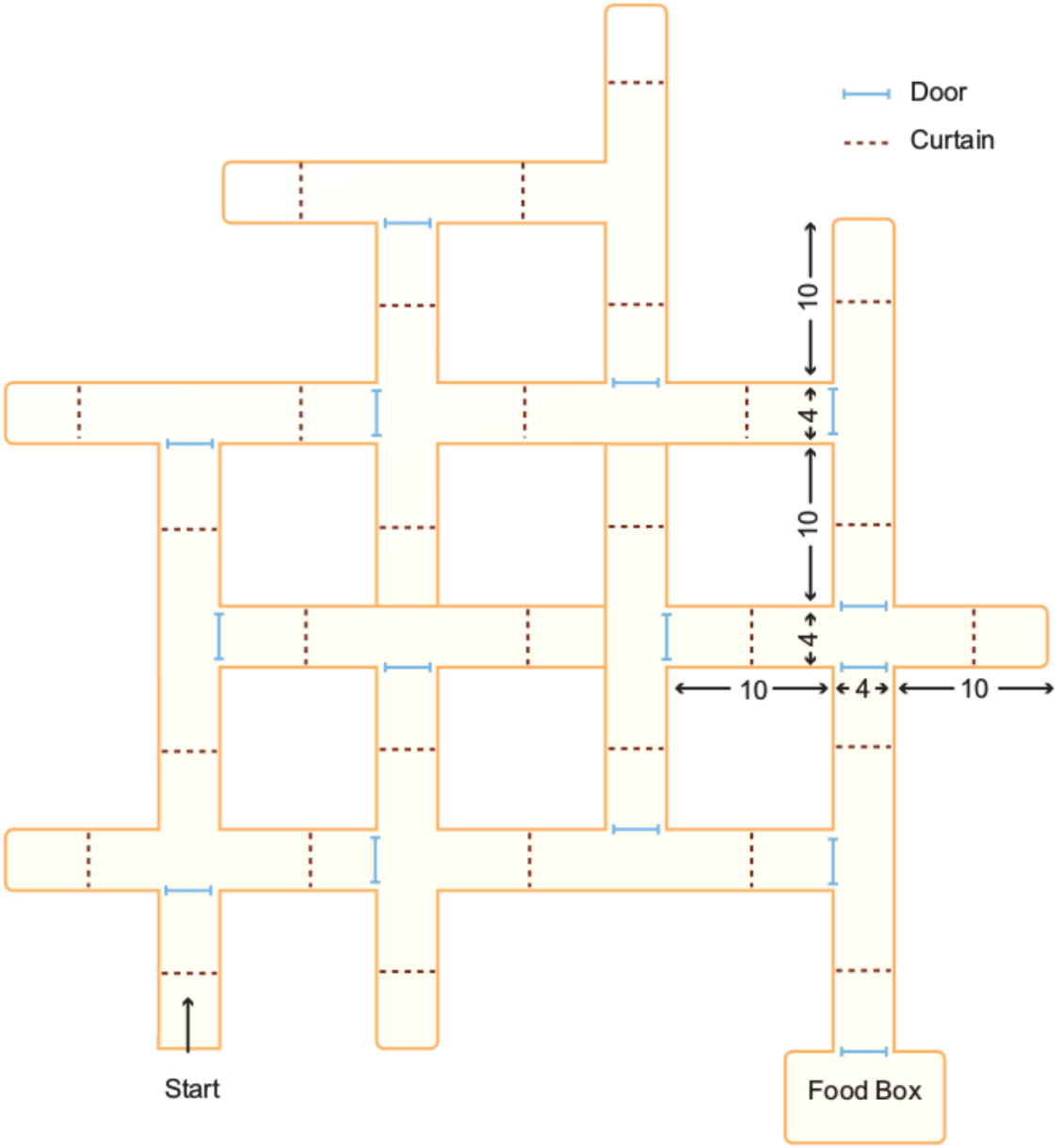


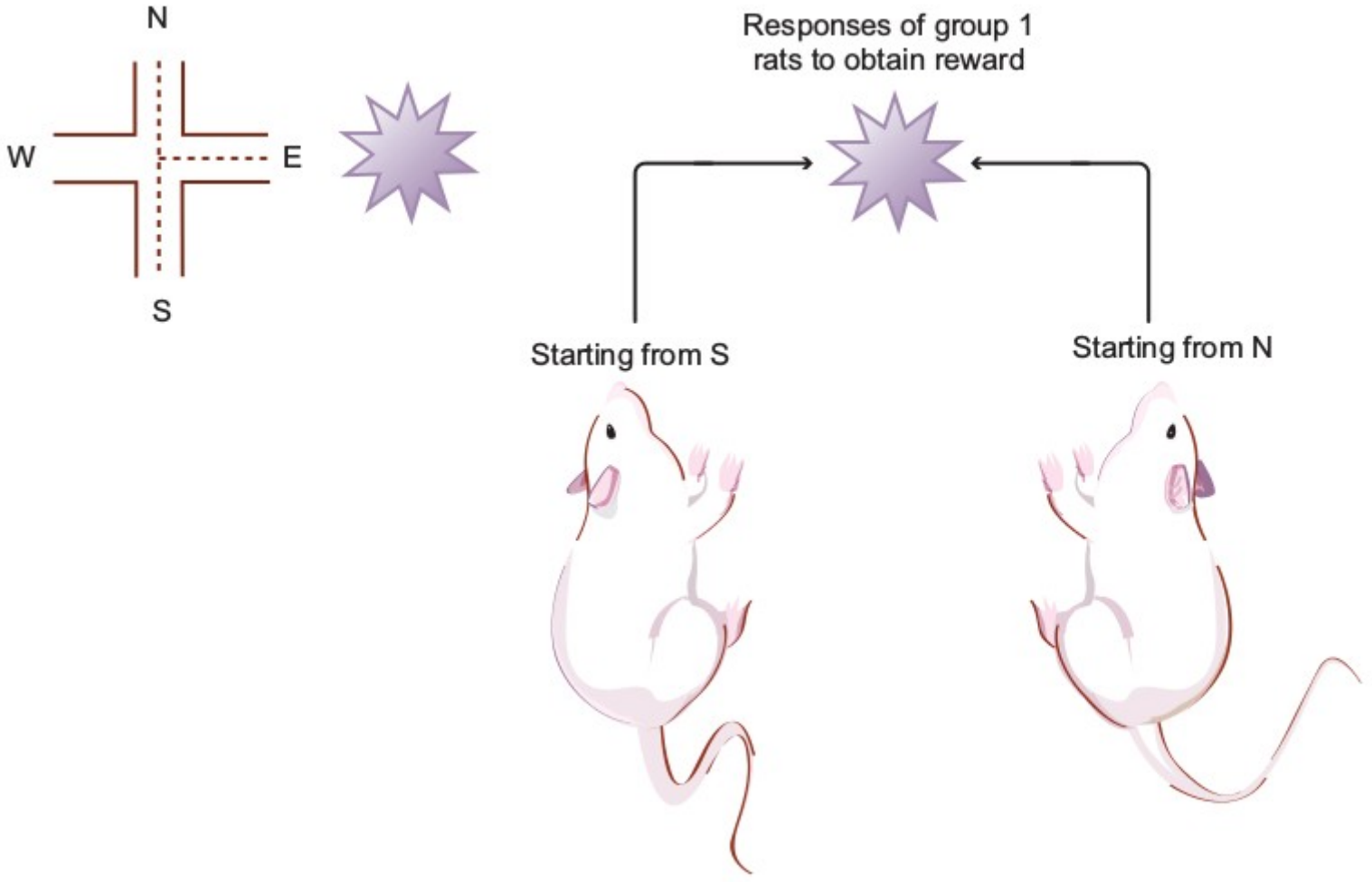
Figure 1.1 A rat in a Skinner box. The rat has a response lever controlling the delivery of food, as well as devices allowing different types of stimuli to be produced. (Adapted from Spivey 2007)

- John B. Watson: against the view that conscious experience is the province of pscyhology
- Data must be open to public inspection
- Behavior is public, consciousness is private
- Almost all behavior is the result of conditioning
- More complicated behaviors can be created from conditioned response units.

Response by Tolman & Honzik 1930



Cognitive maps



Lashley (1951) – Complex behavior

- Previously: complex behavior is a chain of stimulus-responses.
- Lashley:
  - Organized hierarchically
  - Hypothesis of subconscious information processing
  - Hypothesis of task analysis

Other early schools

- Gestalt psychology
  - Gestalt: “form” or “configuration”
  - Max Wetheimer, Kurt Koffka, Wolfgang Kohler
  - The whole is different from the sum of the parts
- Psychoanalysis
  - At the core: concept of unconscious
    - Thoughts, attitudes, impulses, motivations, emotions
    - Show themselves in dreams, slips of tongue
  - Unconscious wishes involved sex or aggression

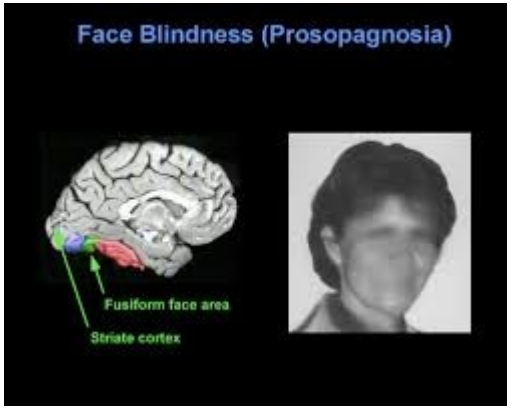
20th century

- 1950's: Computers offer a powerful tool for theorizing about psychological processes through simulation
- Many psychological studies: information-processing models
- Check earlier ideas about mind with concrete terms:
  - Memory as analogous computer stores and retrieves information
  - Transfer from temporary storage in its internal memory to hard drive, from working memory to long-term memory
- Development of modern linguistics: theorize about mental structures required to comprehend and speak a language.
- Information processing models, psycholinguistics, neuropscyhology → cognitive psychology

Psychological Perspectives – Major approaches

Five perspectives within psychology

Biological perspective	An orientation toward understanding the neurobiological processes that underlie behavior and mental processes.
Behavioral perspective	An orientation toward understanding observable behavior in terms of conditioning and reinforcement.
Cognitive perspective	An orientation toward understanding mental processes such as perceiving, remembering, reasoning, deciding, and problem solving and their relationship to behavior.
Psychoanalytic perspective	An orientation toward understanding behavior in terms of unconscious motives stemming from sexual and aggressive impulses.
Subjectivist perspective	An orientation toward understanding behavior and mental processes in terms of the subjective realities people actively construct.



- Following an insult, punch someone in the face
  - Underlying neurobiological processes: Involving brain areas, firing of nerves, activate muscles.
  - Stimulus: insult, response: punch. Not much body reference
  - Mental processes involved: goal is to defend your honor, aggressive behavior is part of achieving such goal.
  - Expression of unconscious aggressive instinct
  - Reaction to interpreting person's utterance as a personal insult

Topics of psychology

- Biological psychology
  - Relationship between biological processes and behavior
- Cognitive psychology
  - Mental processes, problem solving, memory, language, thought
- Developmental psychology
  - Human development, factors (language or period or..)
- Social and personality psychology
  - Perception and interpretation of social world, social relationships
  - Differences between individuals, thoughts/emotions/behaviors
- Clinical and counseling psychology
  - Diagnosis and treatment of emotional and behavioral problems
- School and educational psychology
  - Evaluate learning and emotion problems, teaching. In schools
- Organizational and engineering psychology
  - Job selection, facilitate teamwork, relationship between man and machines

Methods of Psychology

- Experimental method
  - Controlling conditions
  - Measurement
  - Relationships between dependent and independent variables
  - Experimental design
  - Experiment group vs. control group
  - Statistical significance

Design and Analysis of an Experiment

- Identify the issue or question of interest
- Review the relevant theories and research
- Develop research hypothesis
- Identify the independent and dependent variables
- Conduct the experiment
- Use descriptive statistics to evaluate the statistical hypotheses
- Draw conclusions regarding the research hypotheses
- Prepare a formal report for publication or presentation

Keppel et al., Intro. to Design and Analysis

Experimental Method

- Hypothesis: Caffeine affects memory
- Variables: Caffeine amount (indep); amount of recalled items (dep)
- Experiment:
  - Keep all conditions constant
  - Use enough subjects
  - Provide different sets of subjects different amounts of marijuana.Give same information to memorize
  - One week later, see the recalled items

Analysis of results

- Mean (μ): The average of scores
- Median (m): The middle value when we order the scores (more robust to outliers)
- Variance (S): Average of squared deviations from the mean: $\Sigma_i (x_i-\mu)^2 / (n-1)$
-

Correlational method

- What if we cannot control the variables under investigation?

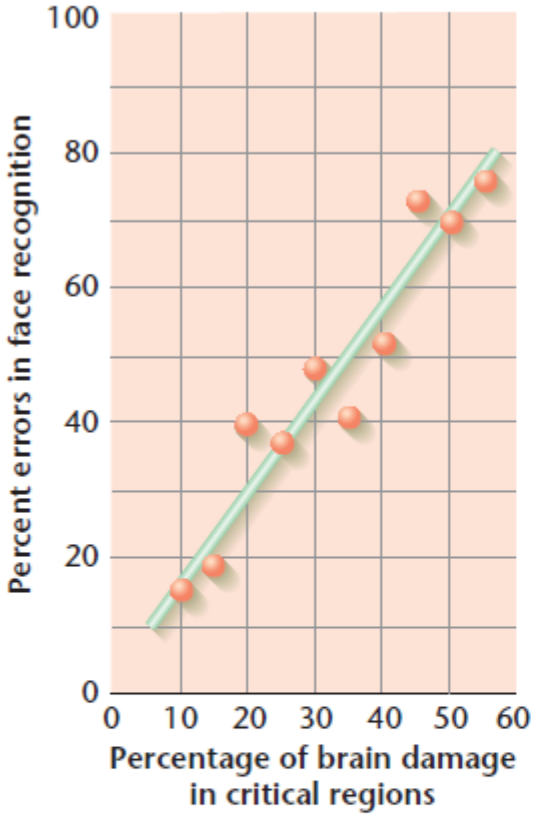
Correlational method

- Correlational method
  - Naturally occurring differences
  - Coefficient of correlation (r)
    - 0: no correlation
    - 1: perfect positive correlation
    - -1: perfect negative correlation
  - Tests
  - Cause-and-effect relations
  - Double dissociation

$$\rho_{X,Y} = \frac{\operatorname{cov}(X,Y)}{\sigma_X \sigma_Y}$$

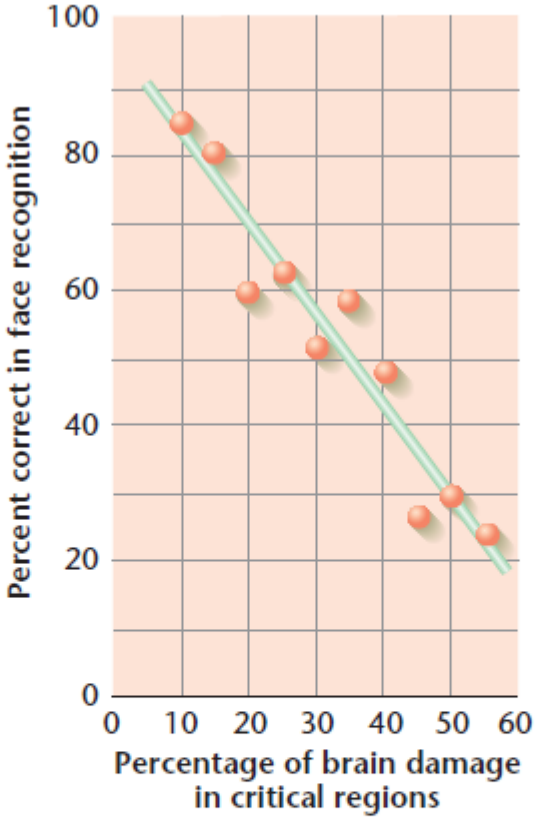
Correlational method

a) Positive correlation



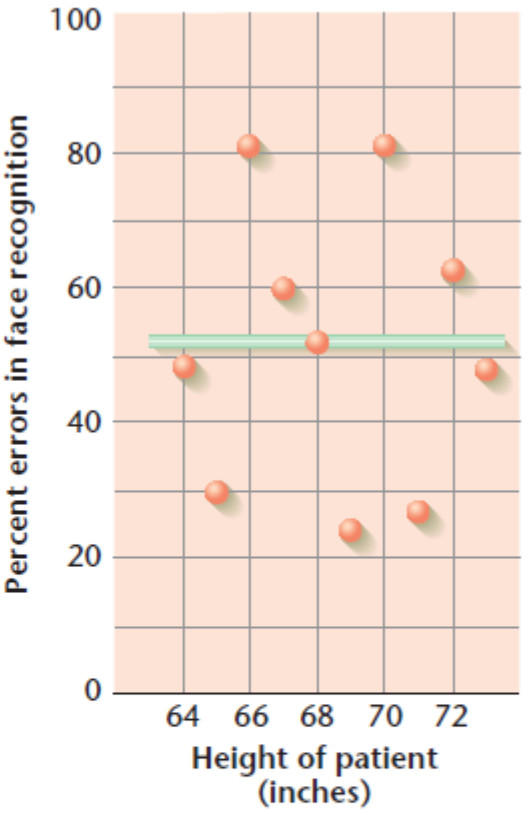
The patients are ordered along the horizontal axis with respect to the amount of brain damage, with the patient represented by the leftmost point having the least brain damage (10%) and the patient represented by the rightmost point having the most brain damage (55%). Each point on the graph represents a single patient's score on a test of face recognition. The correlation is a positive .90.

b) Negative correlation



The same data are depicted, but we now focus on the percentage of correct responses (rather than errors). Now the correlation is a negative .90.

c) Zero correlation



The patients' performance on the face recognition test is graphed as a function of their height. Now the correlation is 0.

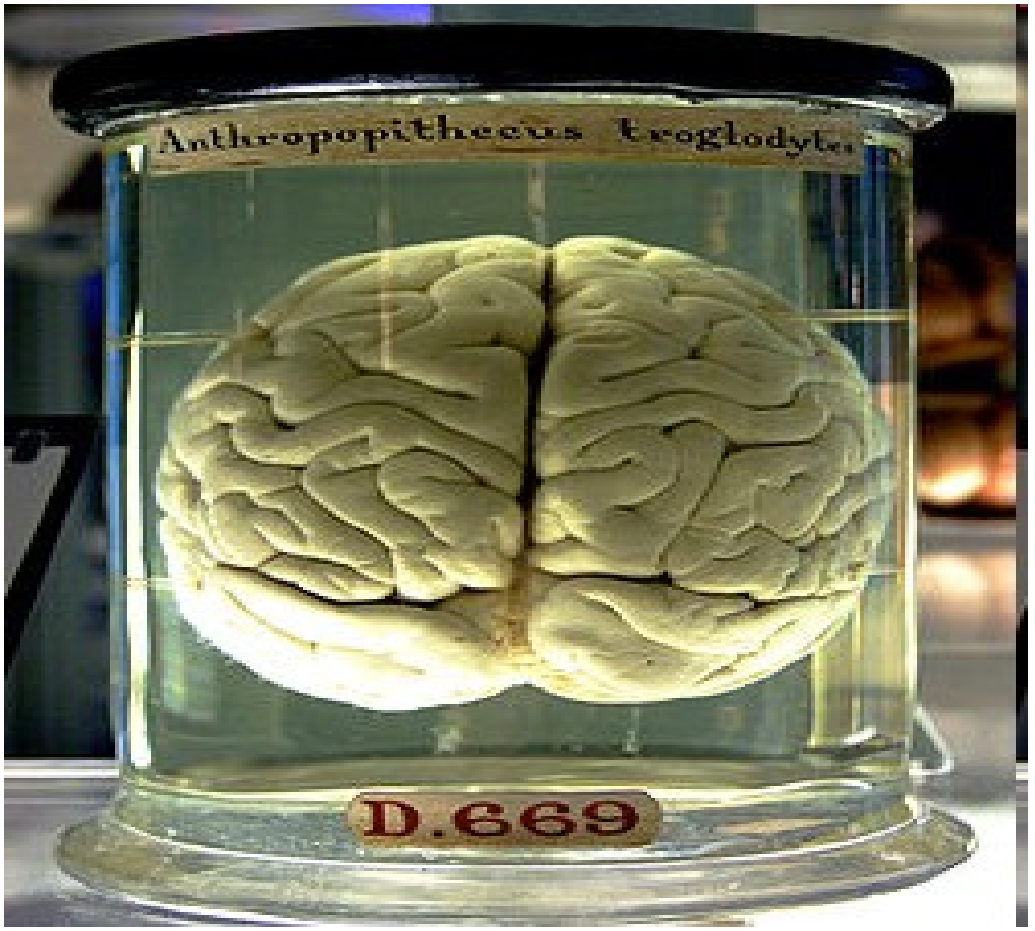
Methods of Psychology

- Observational method
  - Direct observation
  - Survey method
  - Case histories

Field studies can often tell us more about social behavior than experimental studies can. Professor Shirley Strum has been observing the same troop of baboons in Kenya for more than 20 years, identifying individual animals, and making daily recordings of their behaviors and social interactions. Her data have provided remarkable information about the mental abilities of baboons and the role of friendships in their social system.

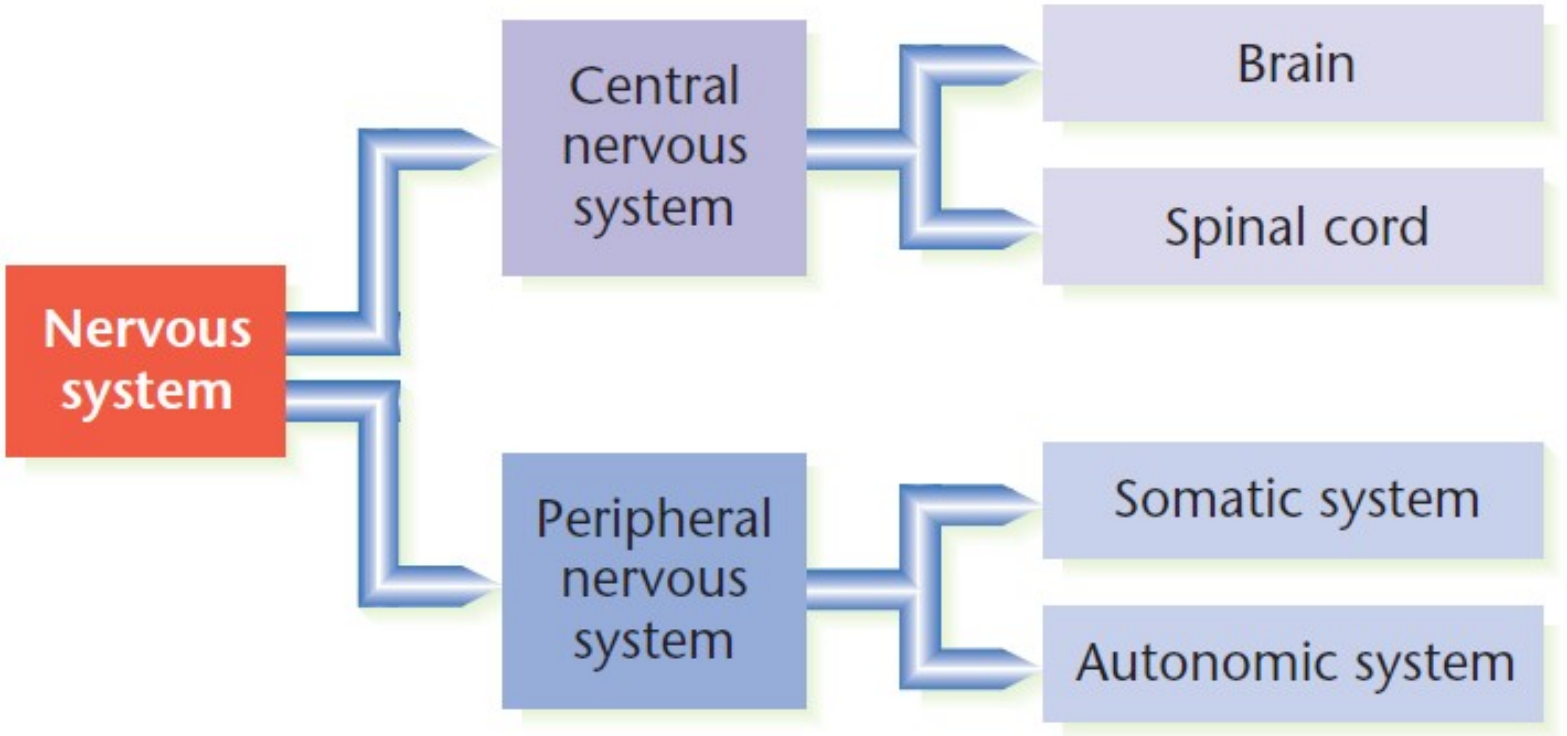
Nervous system and brain

Brain

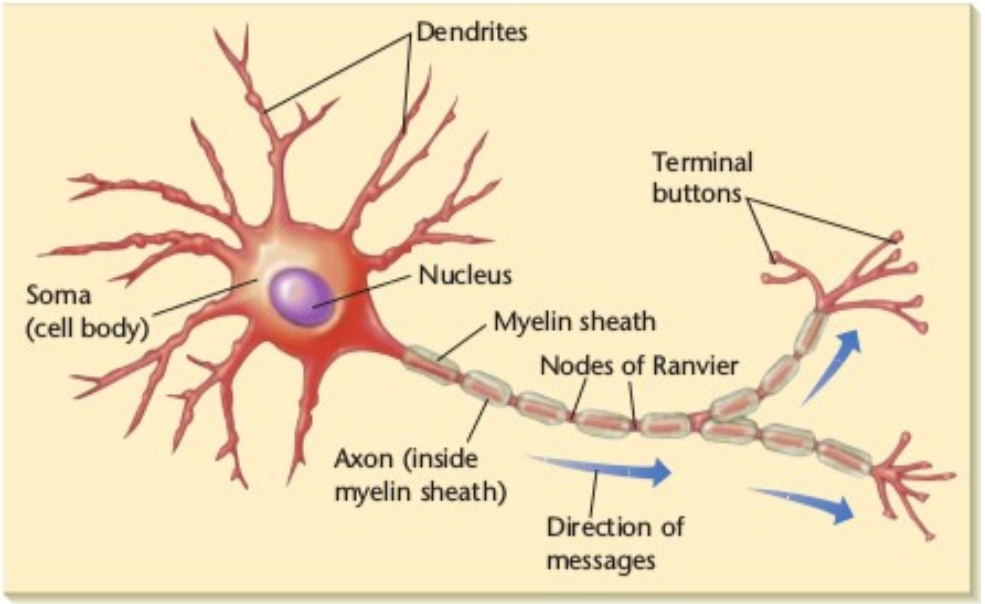


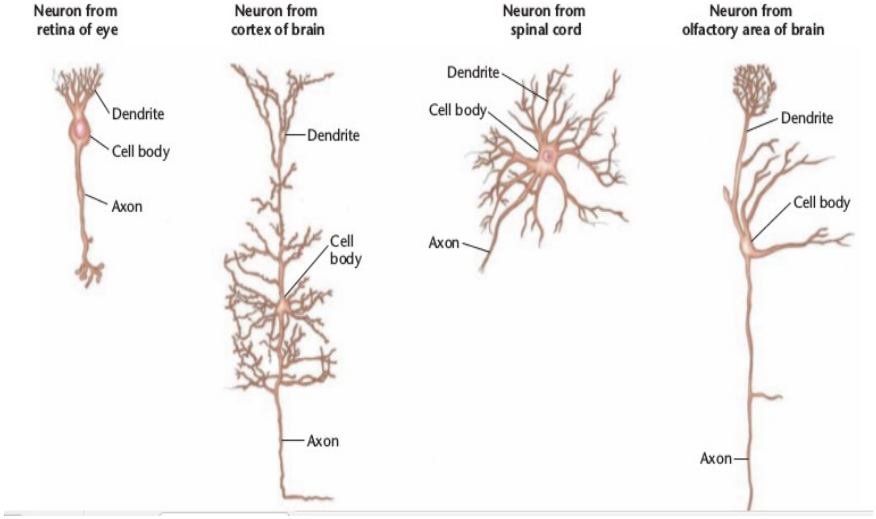
15-30 billion neurons
each thousands of connections

Nervous system



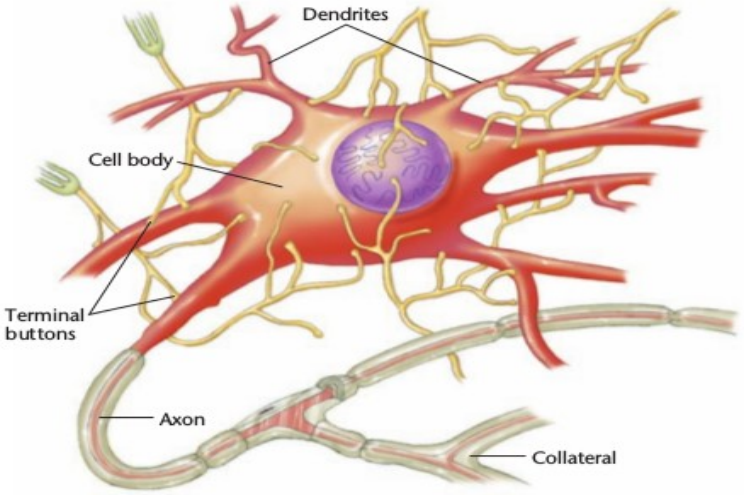
Neurons – basics





- Transmits neural impulses to other neurons, glands, muscles.
- Basics known but..
- Dentrites, soma, axon, terminals..
- Neurotransmitters across gap
- Integrate pre-synaptic impulses

Neurons – basic structure



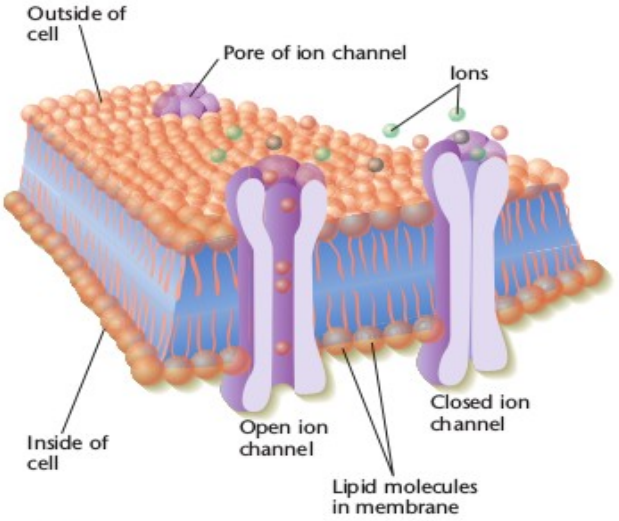
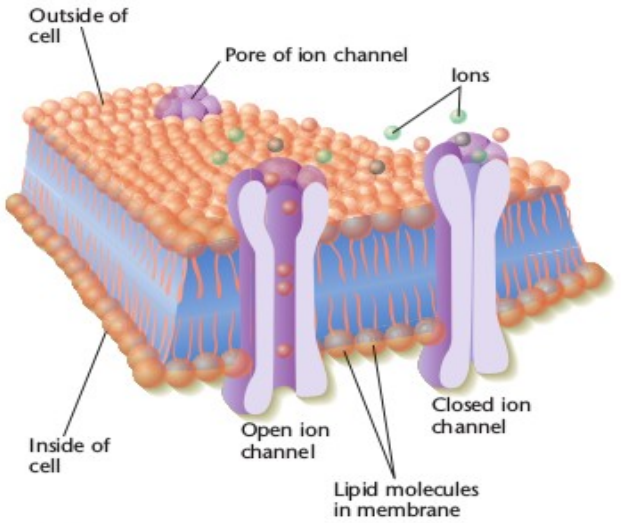


Figure 2.5 Ion Channels. *Ions such as sodium (Na^+), potassium (K^+), and chloride (Cl^-) pass through the cell membrane via doughnut-shaped protein molecules called ion channels.*

- Sensory & motor neurons
- Nerve: a bundle. e.g. optic nerve
- Glial cells more than half of brain – glue and nutrients
- Information moves through electrochemical impulse, movement of ions
- Semi-permeable cell membrane

Neurons – resting state



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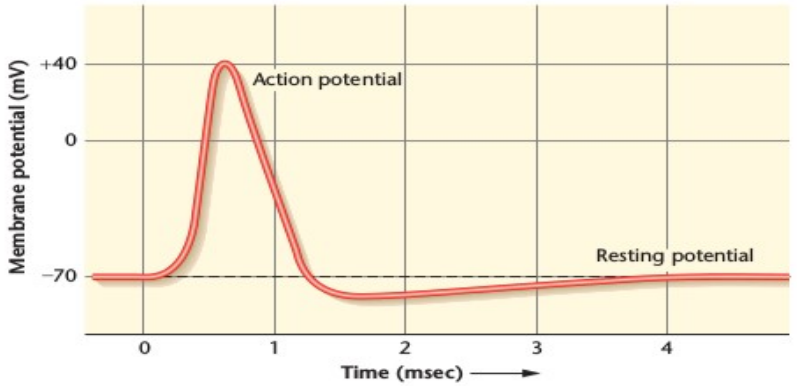
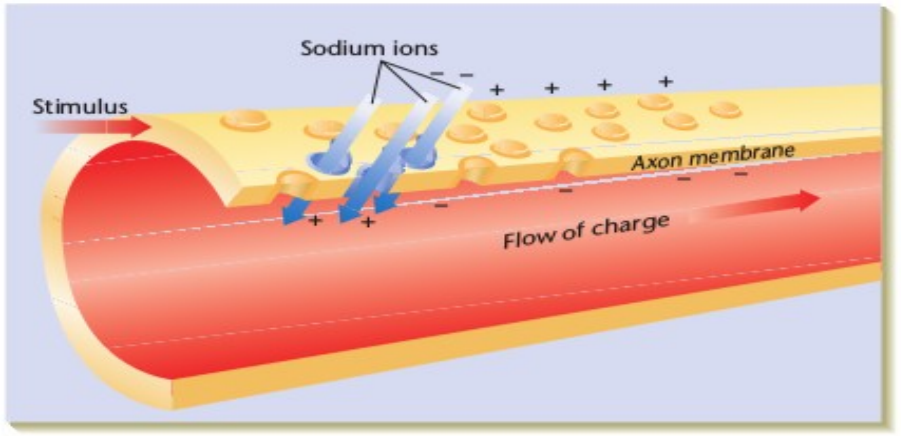
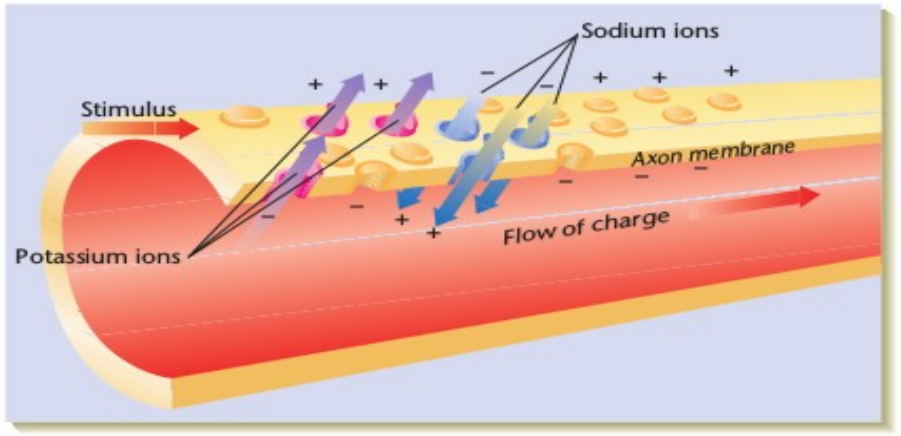


- Resting state: membrane not permeable (high Na^+ outside, K^+ inside)
- Ion channels and pumps
- Action potential from stimulation by other neurons. Caused by neurotransmitters released by pre-synaptic neurons.
- Change small: ion pumps restore
- Excitation threshold: -55 mV

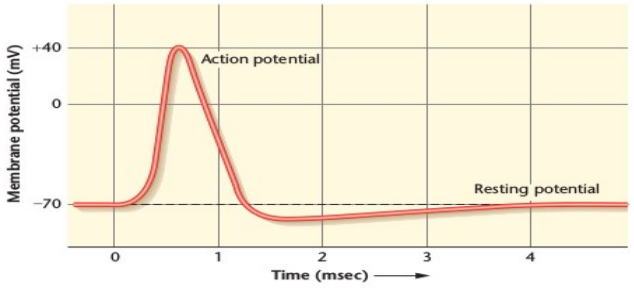
Neurons – action potential



a) During an action potential, sodium gates in the neuron membrane open and sodium ions enter the axon, bringing a positive charge with them.

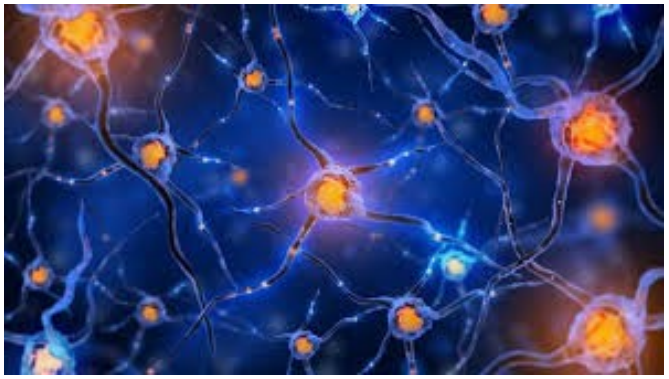


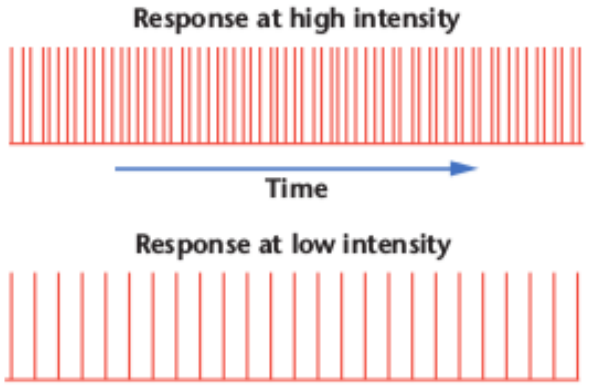
e axon, the sodium
long the axon. When
tassium ions flow



- Unstable membrane
- Na^+ ions in
- inside +40 mV
- Ion pumps restore
- “spike” in only milliseconds
- Refractory period. only in one direction

Neurons - characteristics





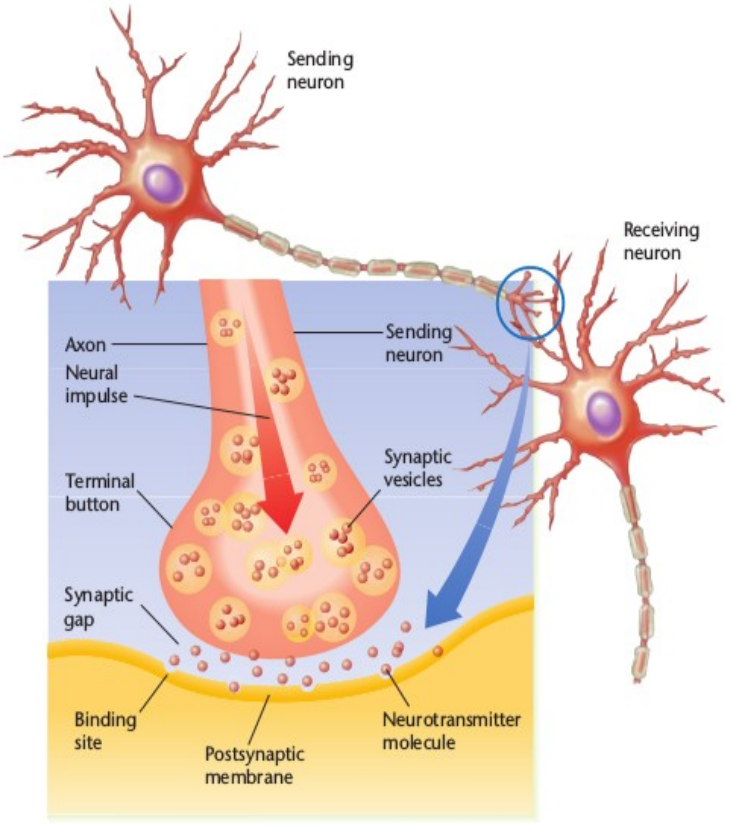
Speed – myelin shealth
Excitatory - inhibitatory

All a neuron can do: fire!

- Single brief pulse
- Threshold level
- Response size same
- All-or-none law

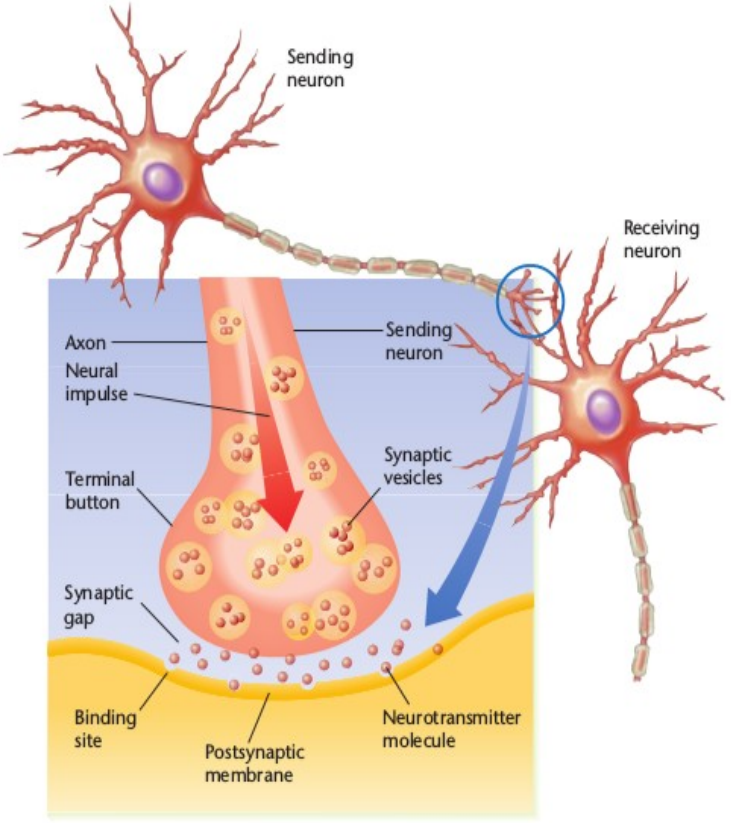
How to code complexity? If basic is so simple.

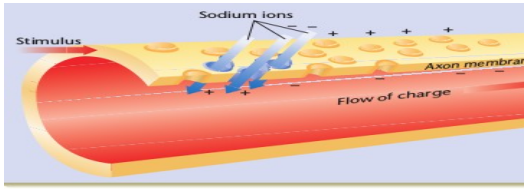
Neurons - synapse



- Not connected
- Stimulate synaptic vesicles that contain neurotransmitters
- Diffuse from neuron and bind to receptors (proteins) in the dendritic membrane – lock&key
- Change permeability of ion channels
- Excitatory or inhibitory
- Excitatory: towards reaching excitation threshold

Neurons – input summation





- Receive from many.
- Summates the input it receives
- Excitatory effect > inhibitory effect
- Depolarization

Neurotransmitters

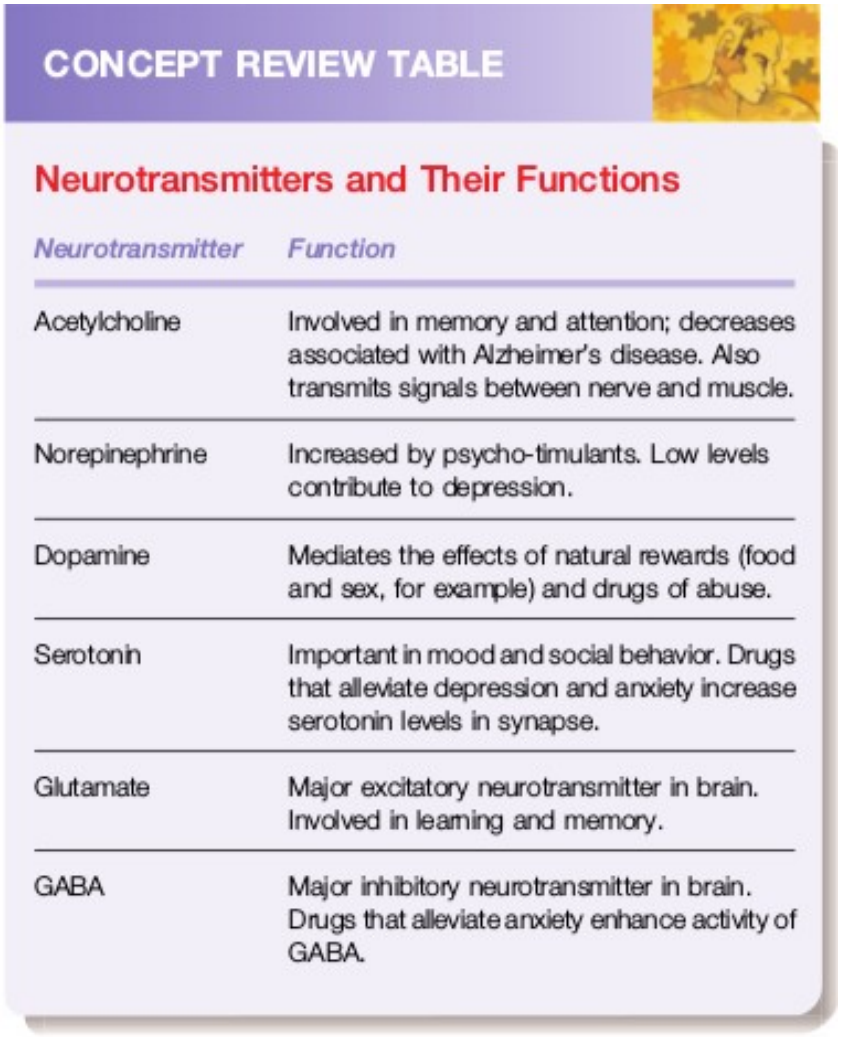
More than 70.

Different types: Some can bind to more than one type of receptor.

Acetylcholine, Norepinephrine, GABA, Glutamate, Serotonin, Dopamine

Dopamine: release in certain areas produces intense feelings of pleasure.

Serotonin: mood regulation. Low levels: associated with feelings of depression.

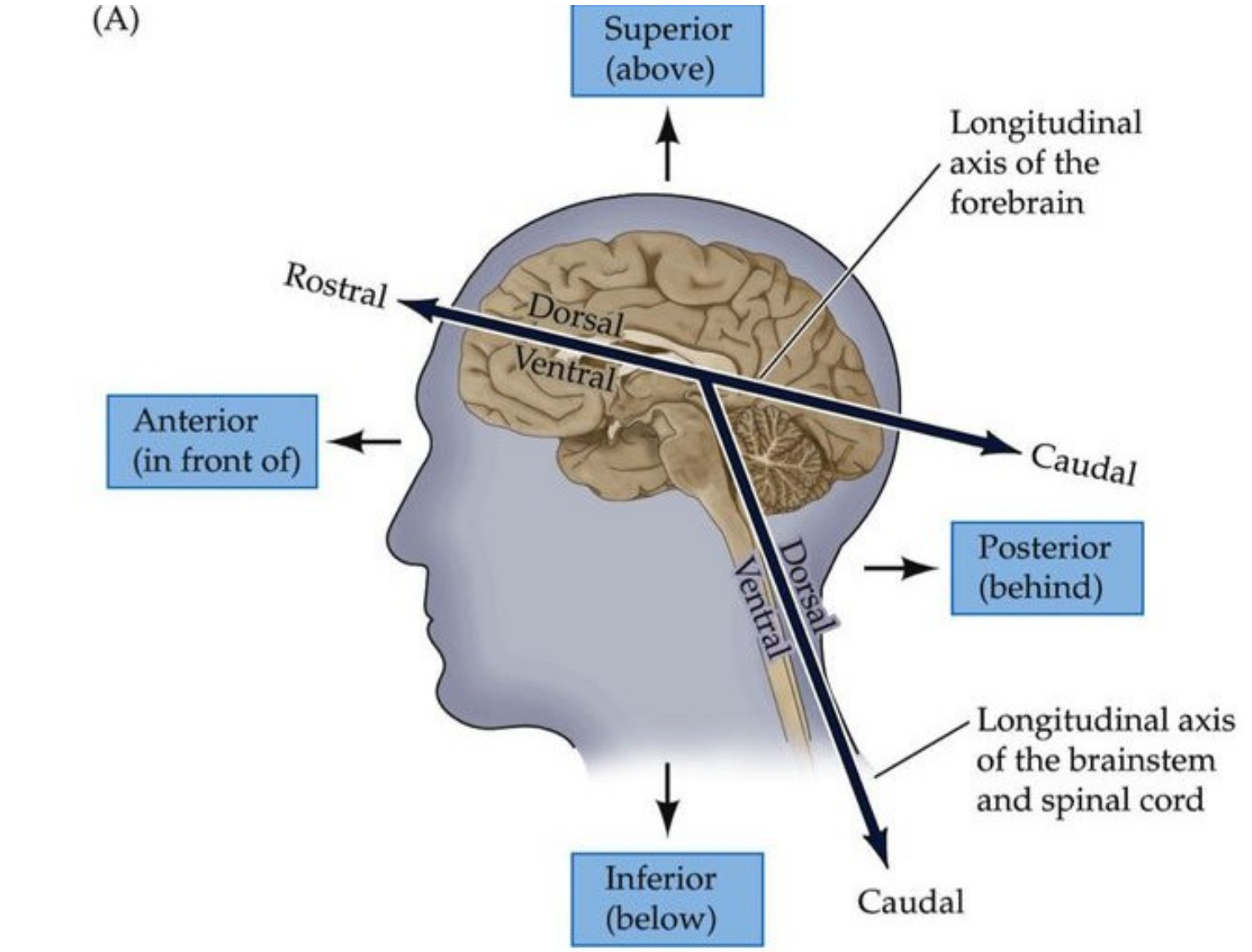


CONCEPT REVIEW TABLE

Neurotransmitters and Their Functions

Neurotransmitter	*Function*
Acetylcholine	Involved in memory and attention; decreases associated with Alzheimer's disease. Also transmits signals between nerve and muscle.
Norepinephrine	Increased by psycho-timulants. Low levels contribute to depression.
Dopamine	Mediates the effects of natural rewards (food and sex, for example) and drugs of abuse.
Serotonin	Important in mood and social behavior. Drugs that alleviate depression and anxiety increase serotonin levels in synapse.
Glutamate	Major excitatory neurotransmitter in brain. Involved in learning and memory.
GABA	Major inhibitory neurotransmitter in brain. Drugs that alleviate anxiety enhance activity of GABA.

Terminology - Directions



https://www.pinterest.co.uk/highup69/neuroscience/

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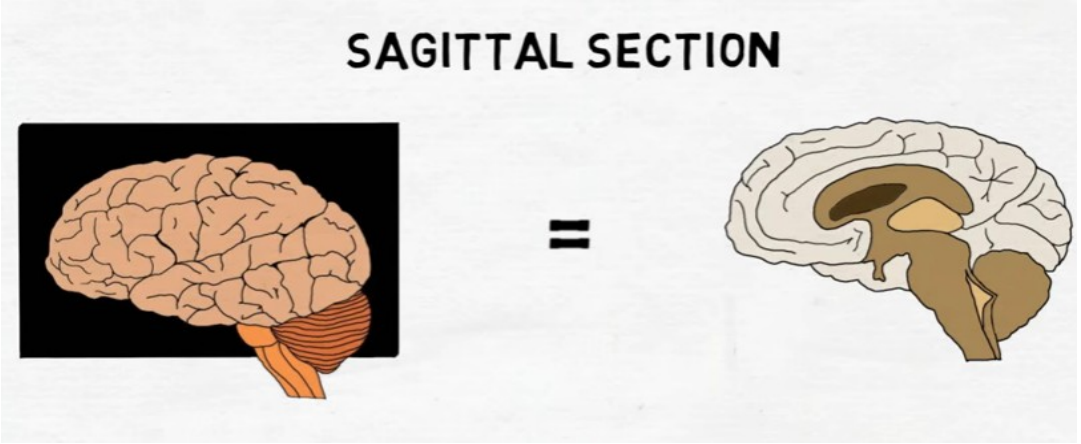
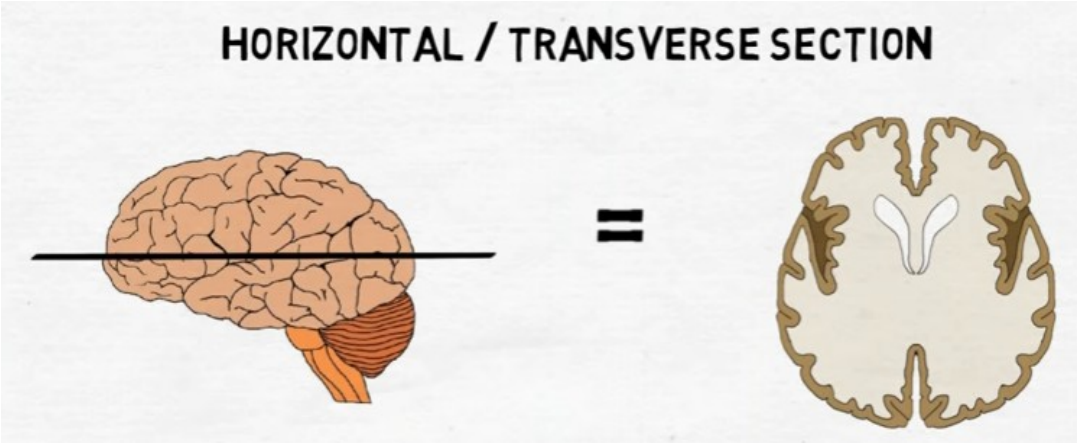
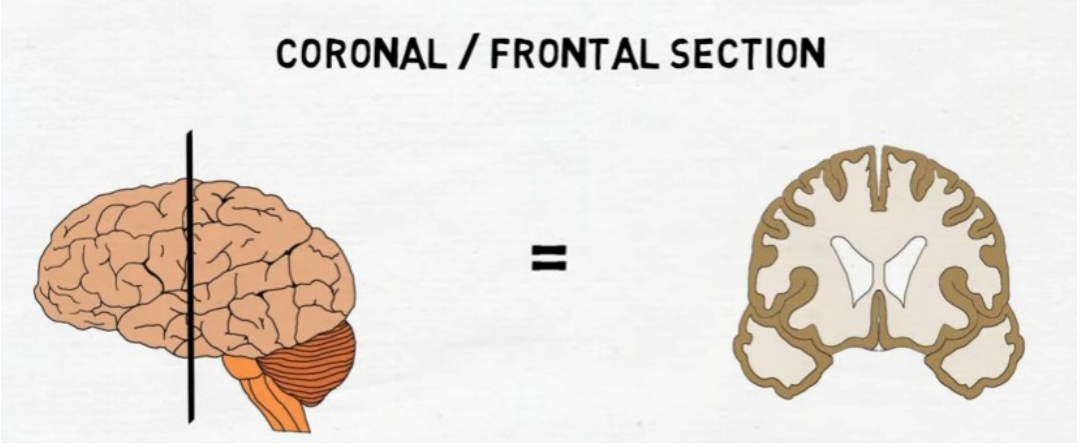
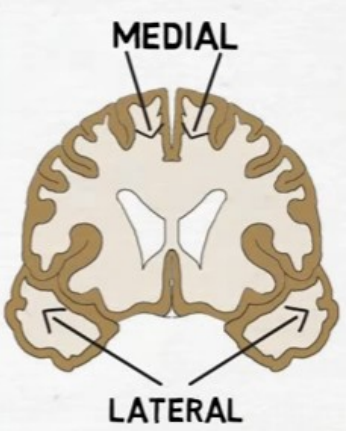
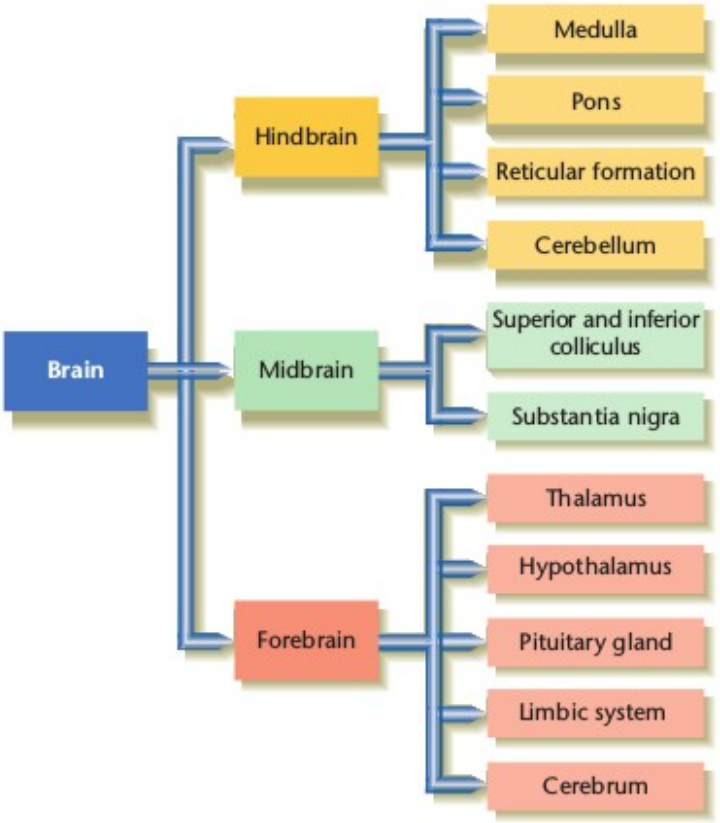


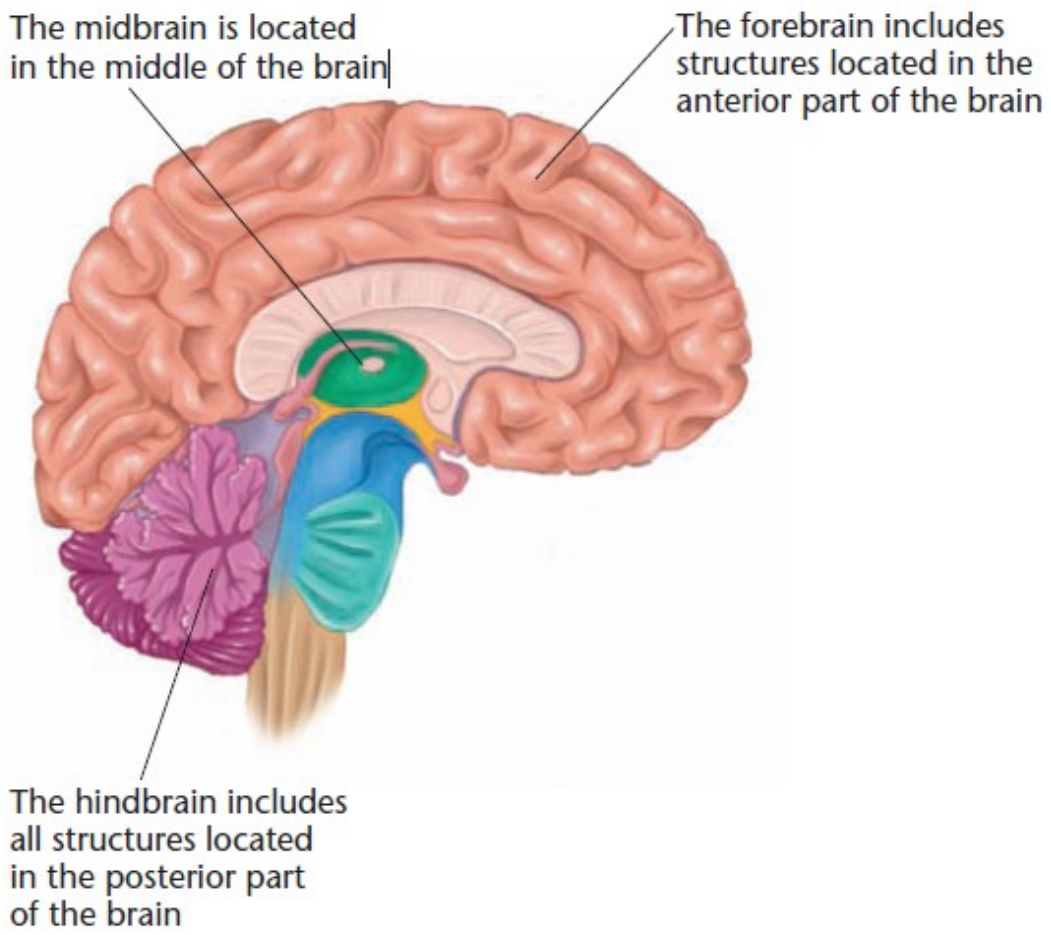






The organization of the brain





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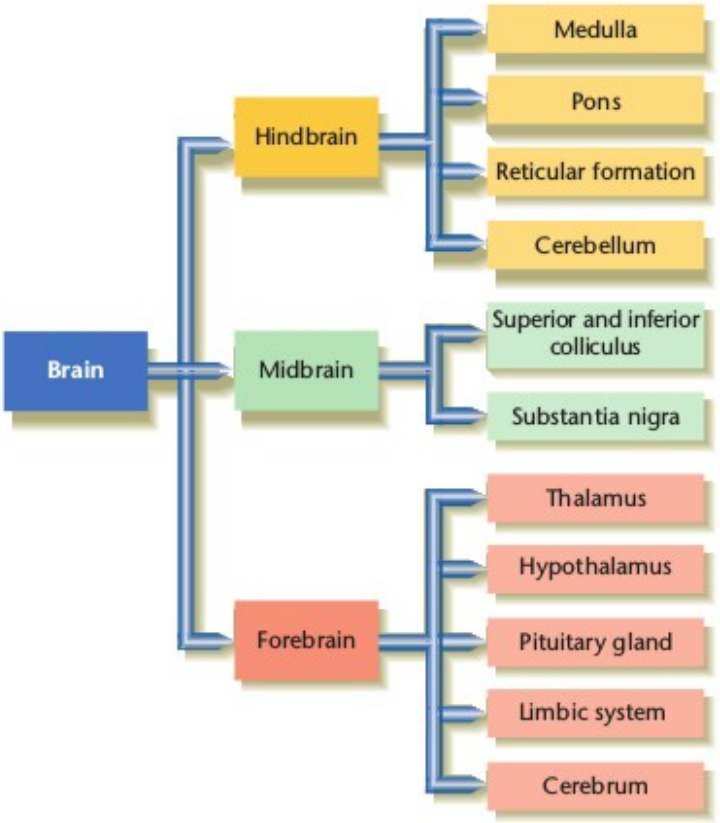
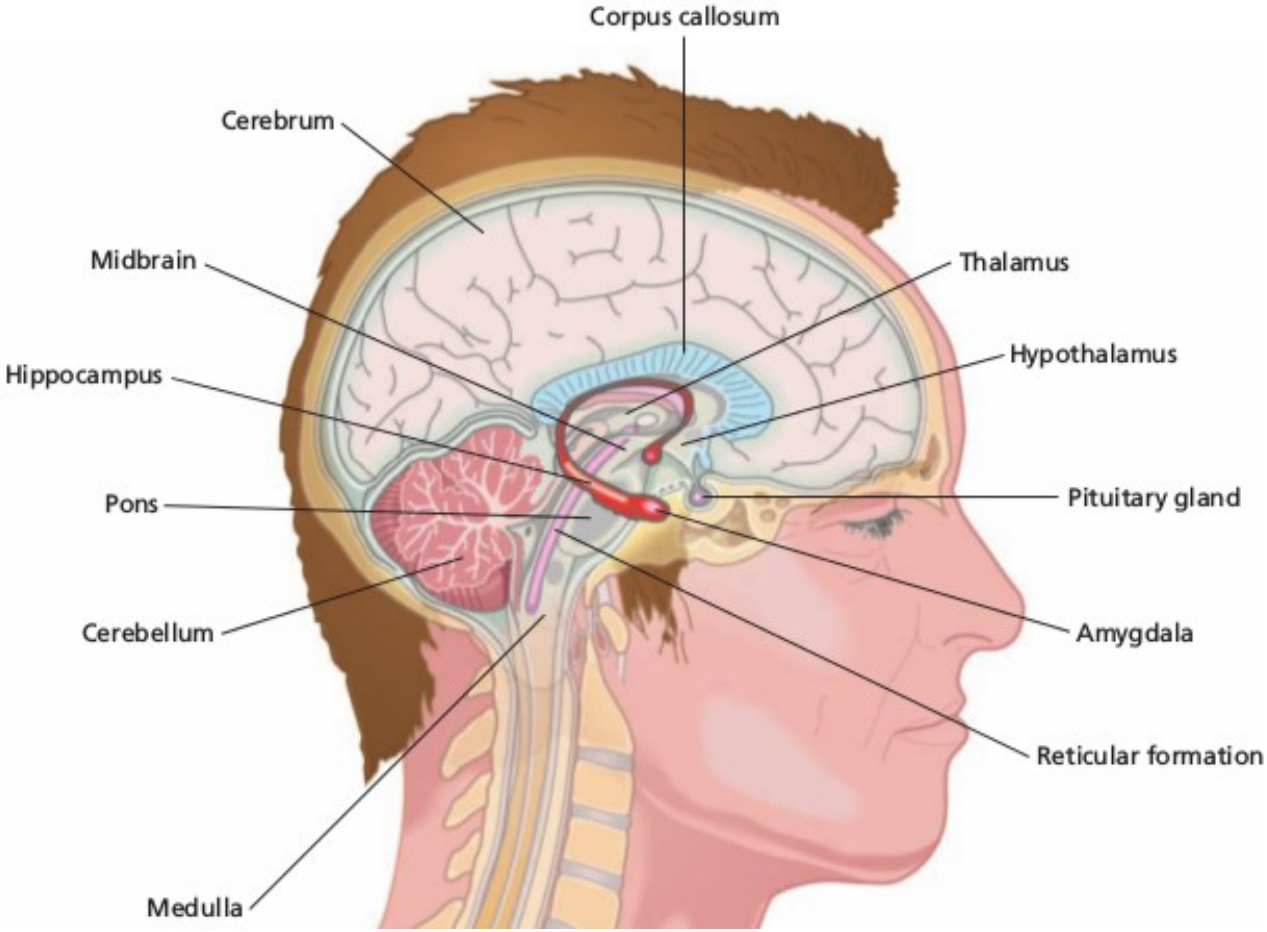
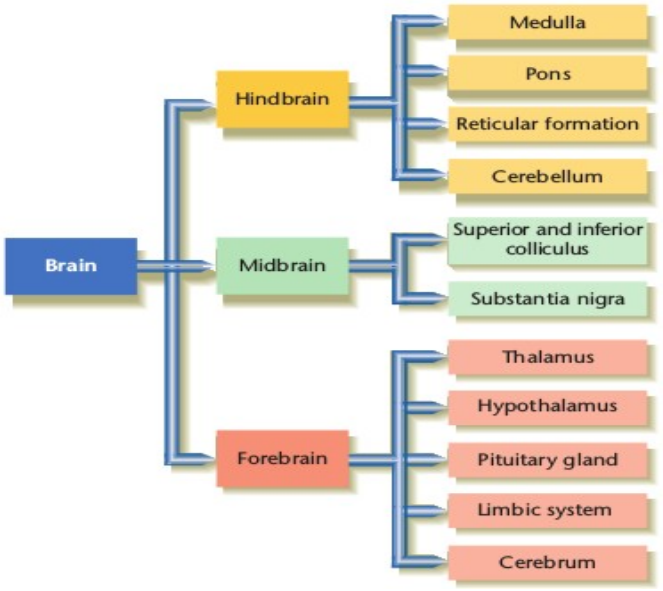
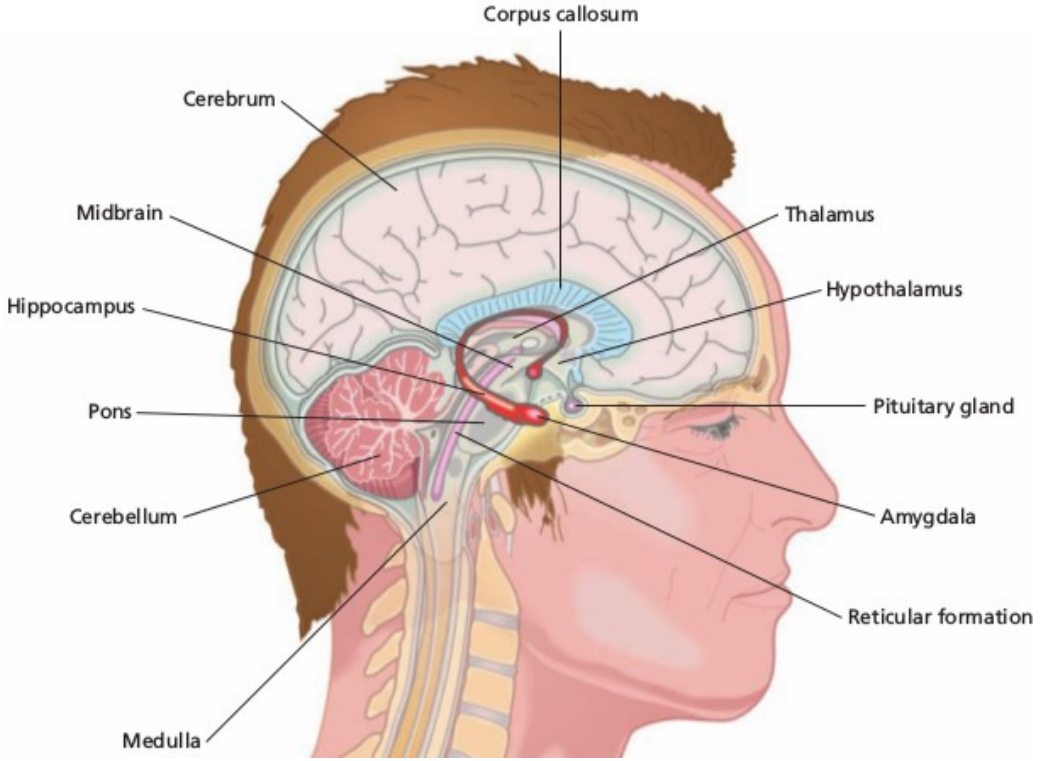


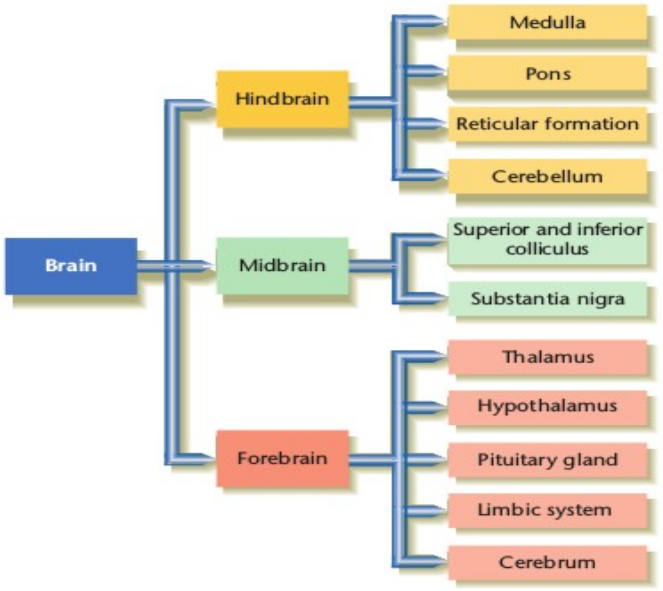


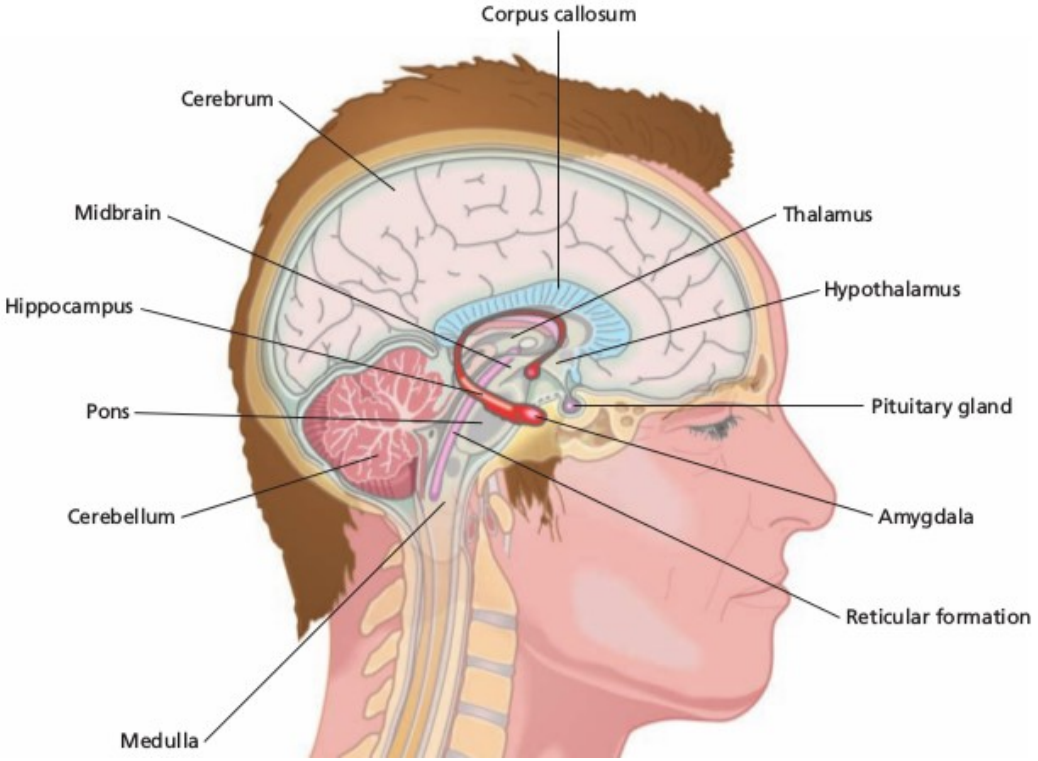




The organization of the brain

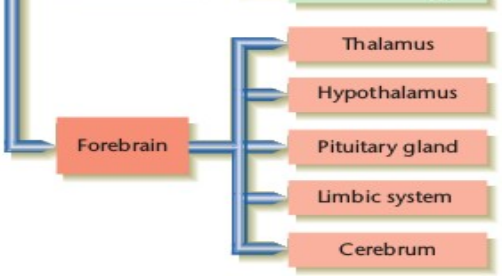
- Medulla: reflexes (breathing and posture)
- Pons: Attentiveness and sleep
- Reticular formation: Behavioral arousal and consciousness
- Cerebellum: coordination of movement. Damage?
  - Learning new movements
  - Direct connections to frontal



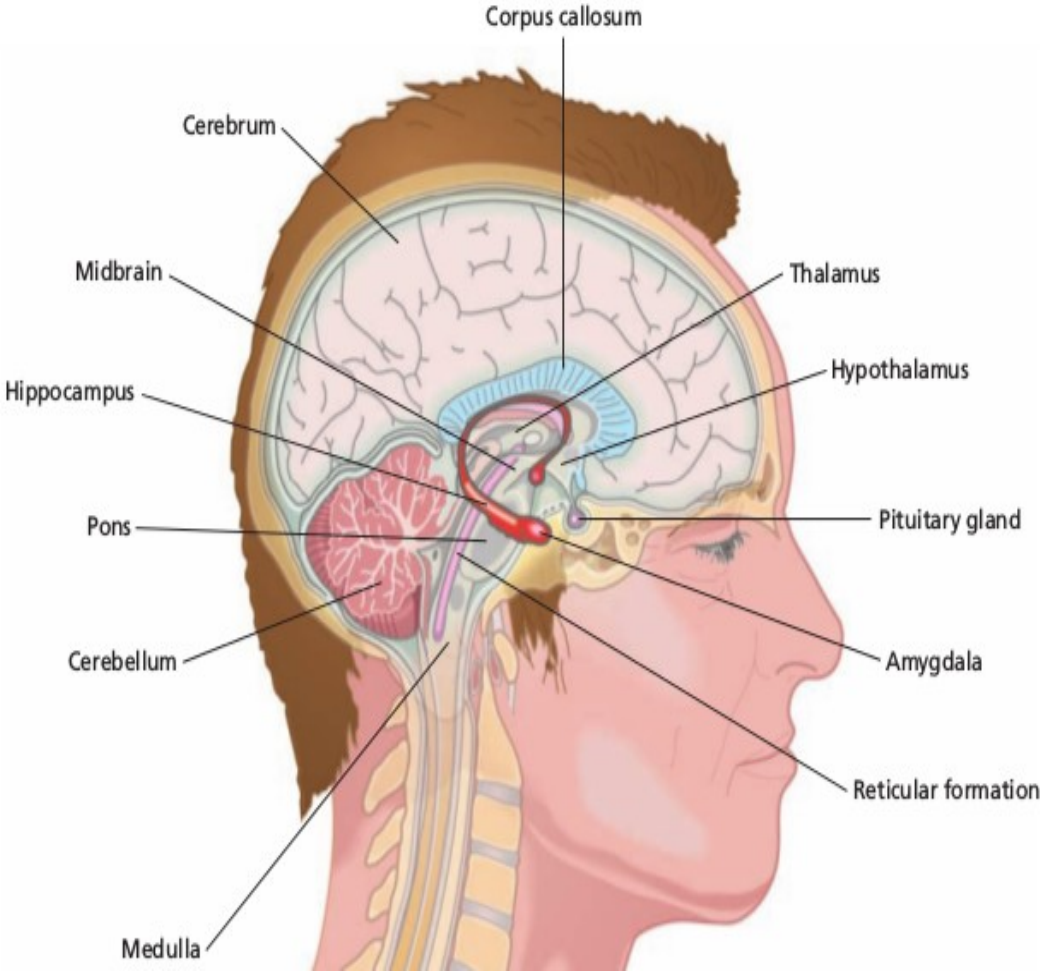


Midbrain

- Relaying sensory information to the brain and for movement control (including eye)
- Important part of dopamine-containing pathway (reward pathway).



Forebrain



Thalamus: sensory relay station.

Hypothalamus: eating, drinking, and sexual behavior.

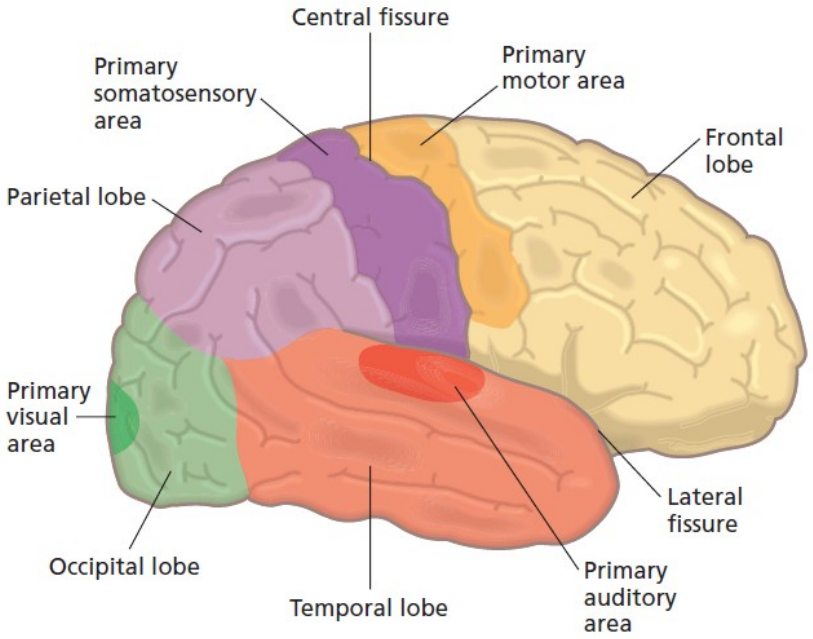
Pituitary gland: part of endocrine sys.

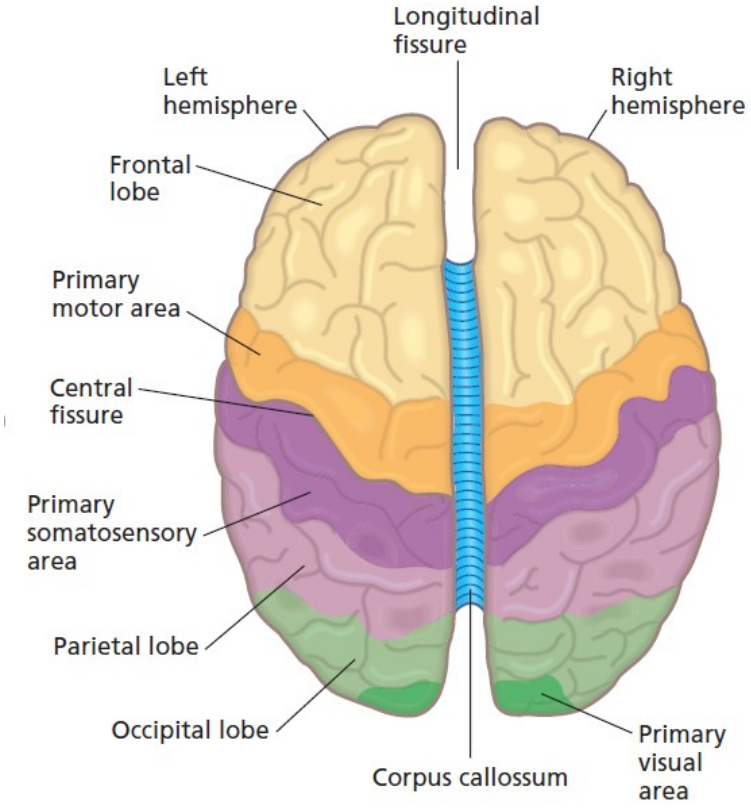
Amygdala: critical in emotions such as fear. Damage in amygdala?

Large cerebrum.

- Upper part: cerebral cortex
- Subcortical: hippocampus, basal ganglia, olfactory bulb
- Hippocampus (part of libmic) role in memory.
- Olfactory bulb: sense of smell
- Basal Ganglia:

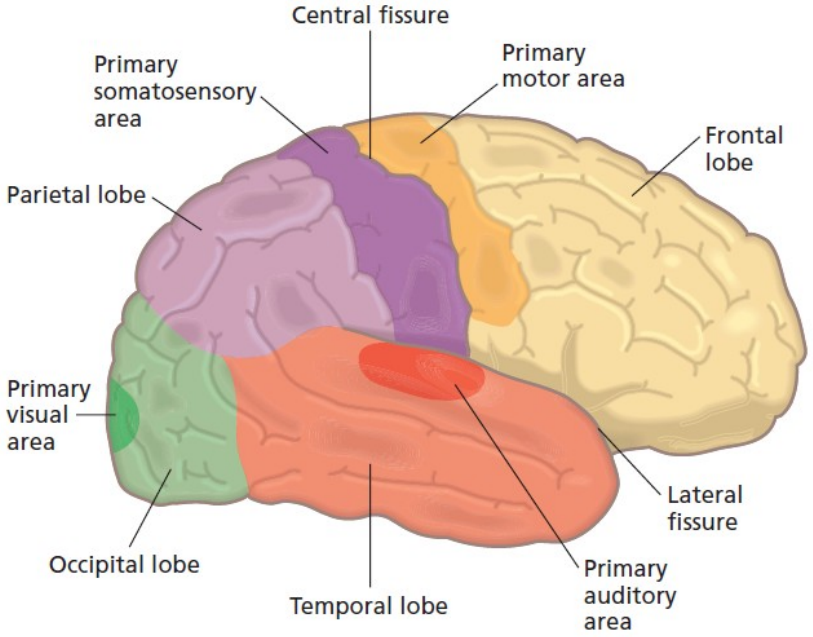
Cerebral Cortex



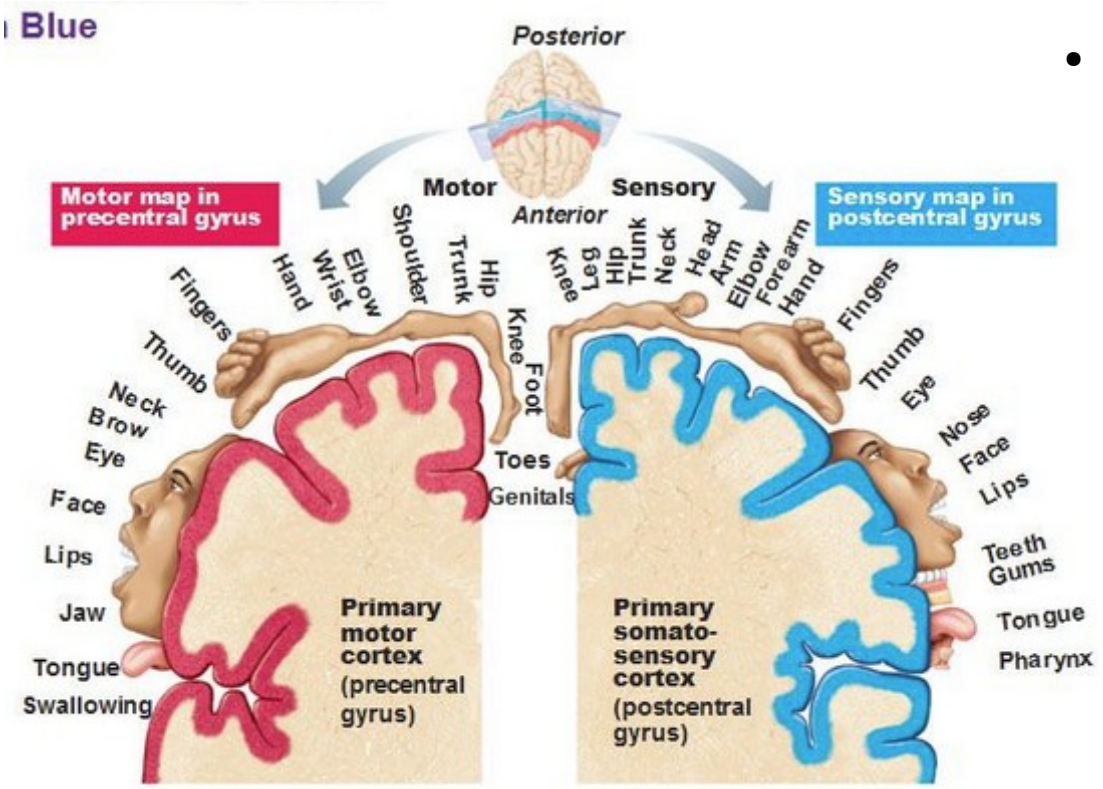


- 2 hemispheres, 4 lobes.
- Gray matter vs. white matter.
- Left and right sides are connected by corpus callosum. Symmetrical.
- Frontal/parietal : central fissure
- Lateral fissure: sets off the temporal
- Specific sensory and motor areas

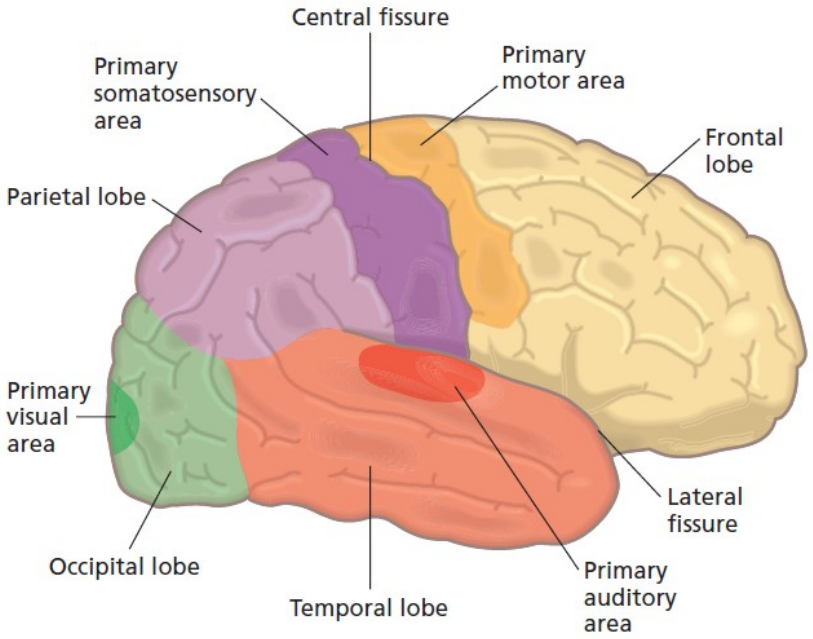
Cerebral Cortex Sensory/motor



- Primary motor area: controls voluntary movements.
- Body is represented upside down.
- Right part controlled/sensed by left.
- Sensory experiences: primary somatosensory area. Stimulation
  - Amount of somatosensory area associated with a part's sensitivity and use.



Cerebral Cortex Sensory/motor



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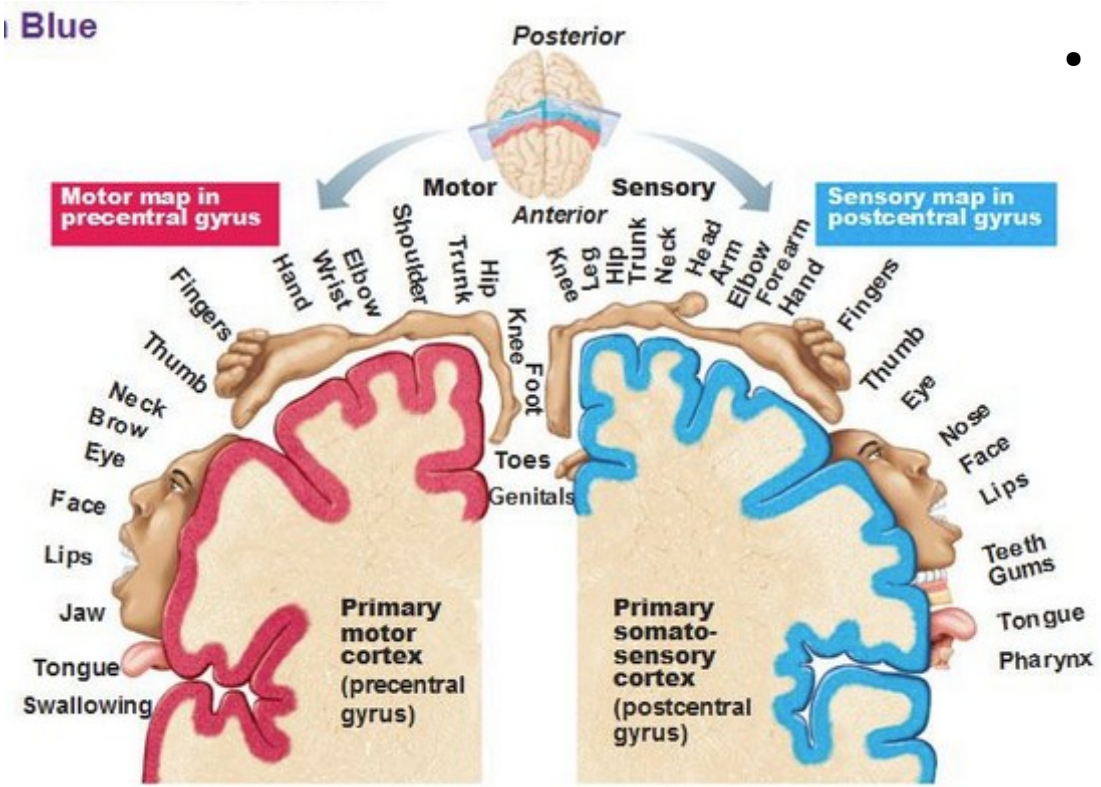
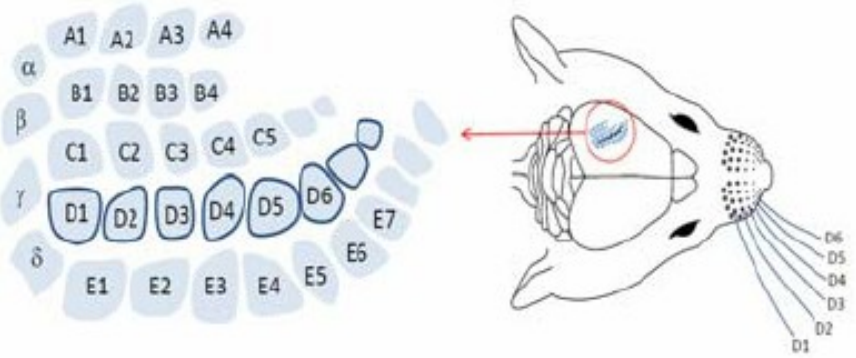
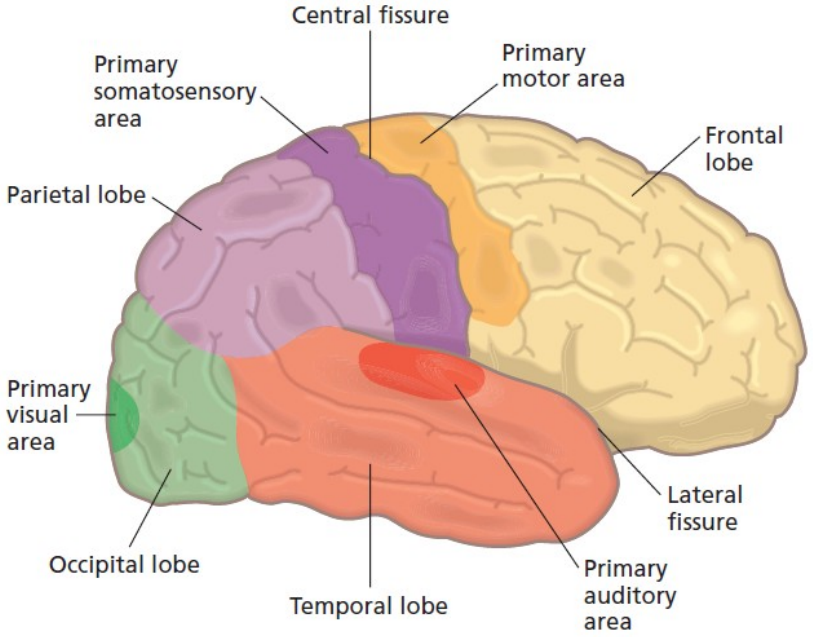
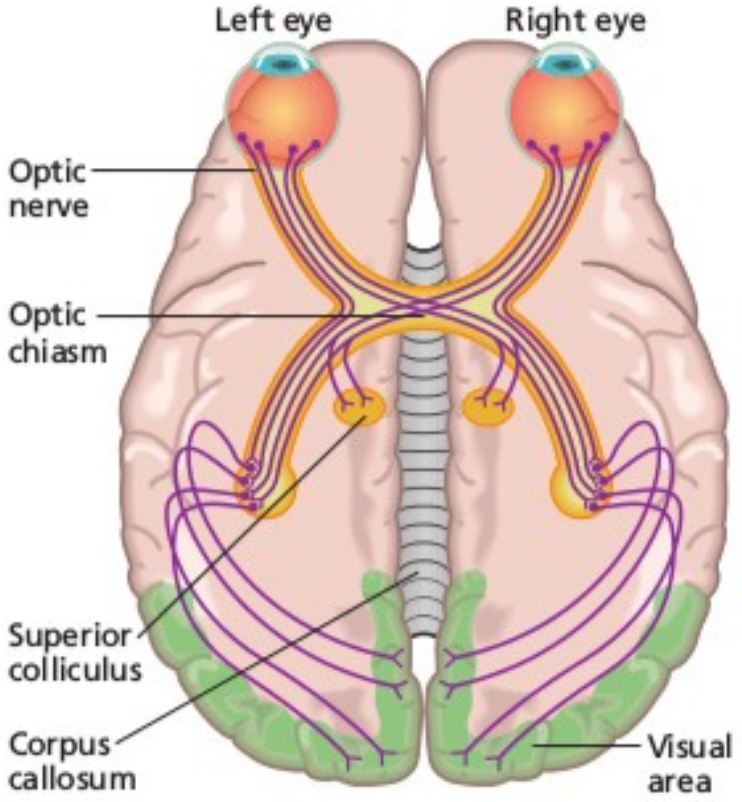




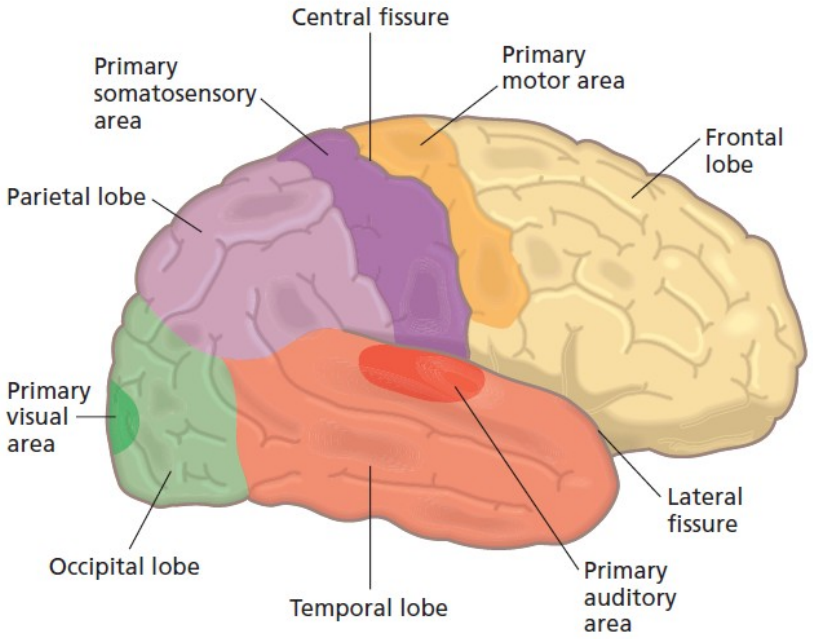
Cerebral Cortex Visual/auditory



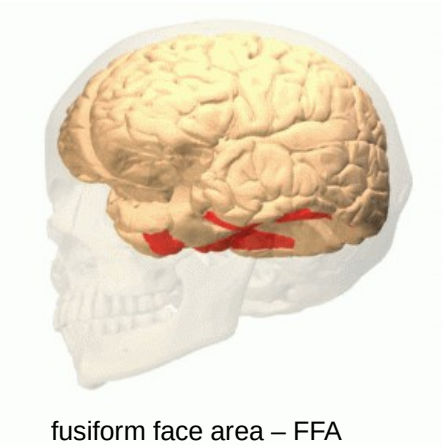
- Primary visual area.
- Primary auditory area



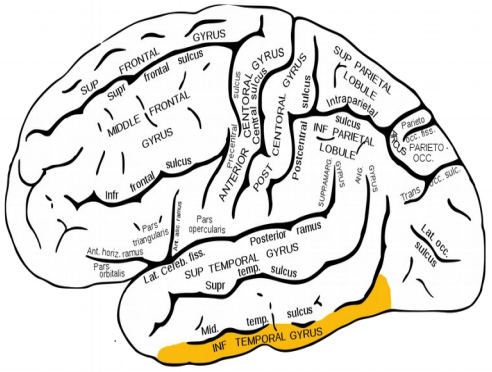
Cerebral Cortex



- Areas not concerned with sensory or motor are **association areas**.
- Frontal association areas: memory in problem solving. with damaged frontal lobe (Miller & Cohen, 2001)
- Posterior association areas: near primary sensory areas, lower temporal lobe is for visual perception.



fusiform face area – FFA
prosopagnosia



Inferior temporal gyrus,
Visual agnosia